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(54) Name of the invention:

Aerial Power Transmission Line

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(71) Patent Assignee: Furukawa Electric Co. LTD.

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[Note: Names, addresses, company names and brand names are translated in the most common manner. Japanese language does not have singular or plural words unless otherwise specified by a numeral prefix or a general form of plurality suffix.]

Description of the invention

1. **Name of the invention**

Aerial Power Transmission Line

2. **Scope of the Claims**

Aerial power transmission line characterized by the fact that it is a line where on the surface of a twisted wire formed from a metal element wire, an intermediate layer is formed that is comprised of at least one type of transition metal from the transition metals from the groups IV, V, and on the surface of that as the outermost layer, an electroconductive ceramics layer is formed that has as its main component at least one type of carbide, nitride, di-boride compound of the transition metals from groups IV, V.

3. **Detailed Explanation of the Invention**

[Technological Field of the Invention]

The present invention is an invention about an aerial power transmission line (including aerial ground lines) with excellent lightning resistant properties.

[Previous Technology and Its Problems]

Generally, as the aerial power transmission lines, single metal lines like bare copper, aluminum, steel etc., or twisted wires where these composite wires have been twisted, are used. In the case of these aerial power transmission line routes, the most frequently generated accidents are the lighting accidents, and it is very strongly desired to discover an aerial power transmission line capable of eliminating these accidents.

In the case of the aerial power transmission lines, through the heat that is generated by the lightning impact electrical flow when a falling lightning is encountered, melting losses, element wire melting separation, etc., are generated, and it has been difficult to prevent these. Taking this into consideration, previously, the aerial power transmission line has been suggested (Japanese Patent Application Hei-Sei 1-80476), where the surface of the twisted wire has been covered by a ceramics layer, which has a melting point that is higher than the melting point of iron, and also, which has electroconductive

properties. In the case of this aerial power transmission line the lightning resistance properties have been significantly improved and an excellent effect has been obtained. However, there has been the drawback that because of the difference in the thermal expansion between the twisted wire and the electroconductive ceramics layer, it has been easy to generate damage like a separation or peeling off of the ceramics layer, etc., and also, it has been easy to generate pin holes at the surface of the twisted wire through stains or defects.

[Problems Solved by the Present Invention]

The present invention is an invention that has been produced as a result from the studies of the above described problems, and it is an invention whereby an aerial power transmission line is invented that has excellent lightning resistance properties and also where the compatibility properties between the twisted wire and the electroconductive ceramics layer are high, and the thermal expansion difference is made to be small, and there are no separation or peeling off of the ceramics layer etc., damages, and also, the surface stains or defects are minimized and the generation of pin holes is suppressed.

[Measures in Order to Solve the Problems and Effect]

The present invention is an aerial power transmission line characterized by the fact that it is a line where on the surface of a twisted wire formed from a metal element wire, an intermediate layer is formed that is comprised of at least one type of transition metal from the transition metals from the groups IV, V, and on the surface of that as the outermost layer, an electroconductive ceramics layer is formed that has as its main component at least one type of carbide, nitride, di-boride compound of the transition metals from groups IV, V.

And namely, in the case of the present invention as an intermediate layer between the twisted wire and the outermost, electroconductive ceramics layer, a layer is used that is formed from the same transition metals as the transition metals used in the carbides, nitrides and di-borides of the transition metals from groups IV and V, which are used as the outermost layer.

The carbides, nitrides, di-borides etc., of the transition metals from groups IV, V, for example, Ti, Zr, Hf, V, Nb, Ta, have strong anti-oxidation properties and anti-sulfidization properties, and their hardness and melting points are high, and their wear is low, and they show good properties, and together with that they are also materials that have good electroconductive properties. Because of that, if the aerial power transmission lines are covered by these materials, the lightning resistance properties of the aerial power transmission line is increased over the lightning resistance properties of the aerial power transmission lines according to the previous technology. Also, the lightning electrical flow time period is on the order of micro seconds, and it is short, and because of that there is little amount of heat transfer from the cover layer to the inner part conductive metal, and it is possible to eliminate the melting loss of the inner part conductive metal material. Then, in the case of aerial ground line, in order to utilize the

lightning hindrance effect, it is necessary that this outer layer be an electroconductive layer, and it is desirable that its bulk electrical resistance coefficient be at or lower than 100 $\mu\Omega$ - cm.

However, in such a state as is, because of the thermal expansion difference existing between the twisted wire and the electroconductive ceramics layer, there is a generation of separation and peeling off of the ceramics layer.

Then, if the electroconductive ceramics layer is directly coated on the twisted wire, there is also the drawback that a misfit of the lattice constant is generated and the crystallization control properties are poor.

Then, according to the present invention, on the surface of the twisted wire, as an intermediate layer, a layer from the same transition metals as those used in the electroconductive ceramics layer, is formed, and by that it is a material where the compatibility properties between the twisted wire and the electroconductive ceramics layer, are high, the thermal expansion difference is made small and together with that the lattice constant misfit is made small.

By doing that, at the interface between the twisted wire and the intermediate layer, the same kind of metals are in contact, and there are the same metals between the intermediate layer and the electroconductive ceramics, and because of that the affinity properties are good and the adhesive properties are improved and together with that the stress due to the thermal expansion difference is relaxed, and the electroconductive ceramics layer damage is eliminated. Then, through the twisted layer/intermediate layer/electroconductive ceramics layer layer lamination, the generation of pin holes is prevented. Then, the lattice constants of the transition metal in the intermediate layer and of the transition metal carbides, nitrides, di-borides in the electroconductive ceramics layer, have close values, and because of that the misfit is made to be small, and it becomes possible to have good crystallization control.

However, in the case of the intermediate layer according to the present invention, it has at least one type of Ti, Zr, Hf, V, Nb, Ta, etc., transition metals from groups IV or V, and also, as the outermost layer, conductive ceramics layer, a material is used that has as its main component at least one type from any of the group IV or V transition metals Ti, Zr, Hf, V, Nb, Ta carbides, nitrides, di-borides.

Then, as the metal element wire, copper wire, aluminum wire, steel wire etc., ground aerial power transmission line element wires, can be used.

[Practical Examples]

Here below, an explanation will be provided regarding one practical implementation example of the present invention.

As it is shown according to Figure 1, on a wire obtained as 7 metal element wires (1) with a diameter of 3.2 mm, have been twisted, the transition metal intermediate layer (2) has been covered and after that electroconductive ceramics layer (30 formed from group IV, V transition metal carbides, nitrides or di-borides, has been covered, and this is explained in the described example.

Practical Example 1

On a twisted wire obtained by twisting 7 aluminum element wires, by using vacuum vapor deposition, a Zr intermediate layer was coated at a thickness of 20 microns, and after that, ZrB_2 layer with a thickness of 70 microns was formed, and an aerial power transmission line, was manufactured.

Practical Example 2

On a twisted wire obtained by twisting 7 copper element wires, by using vacuum vapor deposition, a Zr intermediate layer was coated at a thickness of 20 microns, and after that, ZrN layer with a thickness of 50 microns was formed, and an aerial power transmission line, was manufactured.

Practical Example 3

On a twisted wire obtained by twisting 7 hard steel element wires, by using sputtering, a Ti intermediate layer was coated at a thickness of 10 microns, and after that, by using reduced pressure plasma, a TiB_2 layer with a thickness of 100 microns was formed, and an aerial power transmission line, was manufactured.

Reference Example 1

On a twisted wire obtained by twisting 7 hard steel element wires, by using plasma melting and injection, a TiB_2 layer with a thickness of 100 microns was formed, and an aerial power transmission line, was manufactured.

Reference Example 2

7 hard steel element wires were twisted and an aerial power transmission line, was manufactured.

The heat cycle testing, the anti-oxidation properties, and the sulfidization resistance properties of the manufactured by the above aerial power transmission lines, were studied. The results from these studies are shown according to the presented in Table 1.

Table 1:

	Heat Cycle Test	Anti-Oxidation Properties	Sulfidization Resistance Properties
Practical Example 1	O	O	O
Practical Example 2	O	O	O
Practical Example 3	O	O	O
Reference Example 1	Δ	O	O
Reference Example 2	-	X	X

Remark) O …………good; Δ……………somewhat good, X………poor; -……..no

Moreover, regarding the heat cycle testing, 100 cycles were conducted where the aerial power transmission line was heated from room temperature to 400oC, and then the apparent separation of the electroconductive ceramics was observed.

Regarding the anti-oxidation (oxidation resistance) properties, the aerial power transmission line was placed for a period of 500 hours in an ambient atmosphere at a temperature of 400oC and the degree of the oxidation was observed through the state of its surface. Also, regarding the sulfidization resistance properties, the aerial power transmission line was placed for a period of 1000 hours in an ambient atmosphere of 10 ppm of hydrogen sulfide and at a relative humidity of 90 %, and then its surface state was observed.

As it can be seen from Table 1, the aerial power transmission line according to the present invention has good oxidation resistance properties and sulfidization resistance properties and from the heat cycle testing it is understood that there is no damage of the electroconductive ceramics layer due to the thermal expansion difference.

[Results]

As it is clear from the above described, according to the present invention an aerial power transmission line is obtained that has lightning resistance properties, and also, where the adhesive properties are improved and together with that the stress due to the thermal expansion is relaxed, and the electroconductive ceramics layer damage is prevented, and then, the generation of pin holes has also been prevented, and because of that the present invention has a significant technological effect.

4. **Brief Explanation of the Figure**

Figure 1 is a cross sectional view diagram of the aerial power transmission line pertaining to one practical example of the present invention.

1………………metal twisted wire, 2……….intermediate layer,
3………………electroconductive ceramics layer.

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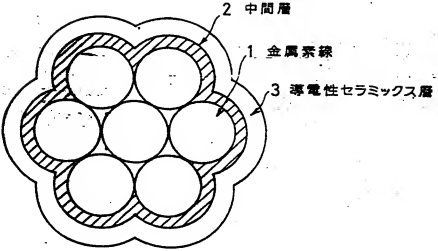

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